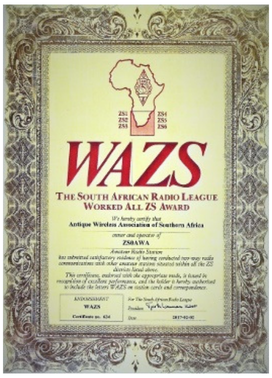
Antique Wireless Association of Southern Africa Newsletter

193

Aug 2022



Inside this issue:

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Reflections:

We've passed the half way mark. The sun is starting to come up a bit earlier every morning (those of us who are up by sunrise will notice it), the fruit trees are starting to blossom (too early me thinks), and the days are slightly warmer by a few degrees.

The end of the year is starting to peak around the corner and all is looking peachy.

For those in the Northern Hemisphere, you will be heading in the opposite direction to us and looking forward to cold days and longer nights.

What exactly does this all mean to us ? Well I for one have kept myself to indoor activities, like playing lots of radio, even with the bands being in the condition they are. I still think we are better off than a year ago this time, so there has been some improvement.

I don't have much in the line of project work around, besides, my workbench is out in the wendy house. Too cold in there, but a few promised things to be done once the weather warms a bit.

I'm sure many of us have thoughts on what we plan to do when the weather does improve, rebuilds, modifications, antenna upgrades etc. Time will tell.

Due to a poor electronics education, I have never really been good at tackling a lot of projects that I would have liked to, but I always had the energy and maybe the "gall" to try and tackle things. I recently helped my grandson complete a project for school, a 12v power supply, and realised how much I had learned over the years of tackling things that I really did not know much about.

I have seen, and felt, many projects go wrong by either components going up in smoke, or simply going "BANG". Shocked myself on a few occasions, fortunately did not destroy any brain cells that I know of, but had lots of fun in the process. That old adage of how good it feels when you have completed something and it actually works, is still the best feeling.

I have made some stupid mistakes in restoration of old rigs, which I must say were very politely pointed out to me by my peers when called in to assist, but I always learned something in the process. Even if it was just how to treat burnt fingertips.

I guess the enjoyment that I get out of doing these things will always supersede the disappointment of failure.

Listening to those with the knowledge of electronics discussing various problems will always intrigue me, although I do tend to get lost sometimes.

Isn't this just such a great hobby ? Much better than flying kites.

(BTW, the smoothing cap on Grandsons PS went bang.)

Best 73

DE Andy ZS6ADY

Wikipedia

Solar Flares:

Description

Solar flares affect all layers of the solar atmosphere (photosphere, chromosphere, and corona). The plasma medium is heated to tens of millions of kelvins, while electrons, protons, and heavier ions are accelerated to near the speed of light. Flares produce electromagnetic radiation across the electromagnetic spectrum at all wavelengths, from radio waves to gamma rays. Most of the energy is spread over frequencies outside the visual range; the majority of the flares are not visible to the naked eye and must be observed with special instruments. Flares occur in active regions often around sunspots, where intense magnetic fields penetrate the photosphere to link the corona to the solar interior. Flares are powered by the sudden (timescales of minutes to tens of minutes) release of magnetic energy stored in the corona. The same energy releases may produce coronal mass ejections (CMEs), although the relationship between CMEs and flares is still not well understood.

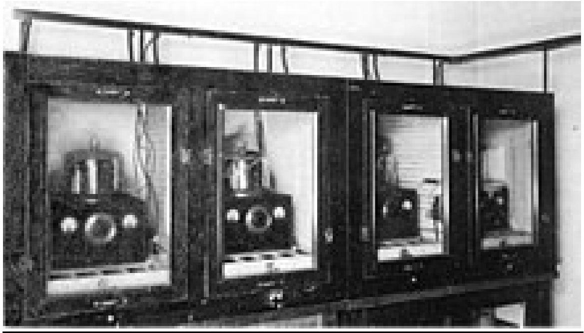
Solar flares occur in a power-law spectrum of magnitudes; an energy release of typically 10^{20} joules of energy suffices to produce a clearly observable event, while a major event can emit up to 10^{25} joules.

Associated with solar flares are flare sprays. They involve faster ejections of material than eruptive prominences, and reach velocities of 20 to 2000 kilometers per second.

CRYSTAL OSCILLATORS

(*As a result of a discussion on the Saturday morning net, I decided to investigate a bit more about crystal oscillators and this is what I came up with. All rights to Wikipedia.)*

A **crystal oscillator** is an electronic oscillator circuit that uses a piezoelectric crystal as a frequency-selective element. The oscillator frequency is often used to keep track of time, as in quartz wristwatches, to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is a quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators. However, other piezoelectricity materials including polycrystalline ceramics are used in similar circuits.



100 kHz crystal oscillators at the US National Bureau of Standards that served as the frequency standard for the United States in 1929

A crystal oscillator relies on the slight change in shape of a quartz crystal under an electric field, a property known as electrostriction or inverse piezoelectricity. A voltage applied to the electrodes on the crystal causes it to change shape; when the voltage is removed, the crystal generates a small voltage as it elastically returns to its original shape. The quartz oscillates at a stable resonant frequency, behaving like an RLC circuit, but with a much higher Q factor (less energy loss on each cycle of oscillation). Once a quartz crystal is adjusted to a particular frequency (which is affected by the mass of electrodes attached to the crystal, the orientation of the crystal, temperature and other factors), it maintains that frequency with high stability.

Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. As of 2003, around two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cellphones. However in applications where small size and weight is needed crystals can be replaced by thin-film bulk acoustic resonators, specifically if high frequency (more than roughly 1.5 GHz) resonance is needed. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes.

Very early Bell Labs crystals from Vectron International Collection

Terminology

A crystal oscillator is an electric oscillator type circuit that uses a piezoelectric resonator, a crystal, as its frequency-determining element. *Crystal* is the common term used in electronics for the frequency-determining component, a wafer of quartz crystal or ceramic with electrodes connected to it. A more accurate term for it is *piezoelectric resonator*. Crystals are also used in other types of electronic circuits, such as crystal filters.

Piezoelectric resonators are sold as separate components for use in crystal oscillator circuits. An example is shown in the picture. They are also often incorporated in a single package with the crystal oscillator circuit, shown on the righthand side.

History

Piezoelectricity was discovered by Jacques and Pierre Curie in 1880. Paul Langevin first investigated quartz resonators for use in sonar during World War I. The first crystal-controlled oscillator, using a crystal of Rochelle salt, was built in 1917 and patented in 1918 by Alexander M. Nicholson at Bell Telephone Laboratories, although his priority was disputed by Walter Guyton Cady. Cady built the first quartz crystal oscillator in 1921. Other early innovators in quartz crystal oscillators include G. W. Pierce and Louis Essen.

Quartz crystal oscillators were developed for high-stability frequency references during the 1920s and 1930s. Prior to crystals, radio stations controlled their frequency with tuned circuits, which could easily drift off frequency by 3–4 kHz. Since broadcast stations were assigned frequencies only 10 kHz (Americas) or 9 kHz (elsewhere) apart, interference between adjacent stations due to frequency drift was a common problem. In 1925, Westinghouse installed a crystal oscillator in its flagship station KDKA, and by 1926, quartz crystals were used to control the frequency of many broadcasting stations and were popular with amateur radio operators. In 1928, Warren Marrison of Bell Telephone Laboratories developed the first quartz-crystal clock. With accuracies of up to 1 second in 30 years (30 ms/y, or 0.95 ns/s),[8] quartz clocks replaced precision pendulum clocks as the world's most accurate timekeepers until atomic clocks were developed in the 1950s. Using the early work at Bell Labs, AT&T eventually established their Frequency Control Products division, later spun off and known today as Vectron International.

A number of firms started producing quartz crystals for electronic use during this time. Using what are now considered primitive methods, about 100,000 crystal units were produced in the United States during 1939. Through World War II crystals were made from natural quartz crystal, virtually all from Brazil. Shortages of crystals during the war caused by the demand for accurate frequency control of military and naval radios and radars spurred postwar research into culturing synthetic quartz, and by 1950 a hydrothermal process for growing quartz crystals on a commercial scale was developed at Bell Laboratories. By the 1970s virtually all crystals used in electronics were synthetic.

In 1968, Juergen Staudte invented a photolithographic process for manufacturing quartz crystal oscillators while working at North American Aviation (now Rockwell) that allowed them to be made small enough for portable products like watches.

Although crystal oscillators still most commonly use quartz crystals, devices using other materials are becoming more common, such as ceramic resonators.

Operation

A crystal is a solid in which the constituent atoms, molecules, or ions are packed in a regularly ordered, repeating pattern extending in all three spatial dimensions.

Almost any object made of an elastic material could be used like a crystal, with appropriate transducers, since all objects have natural resonant frequencies of vibration. For example, steel is very elastic and has a high speed of sound. It was often used in mechanical filters before quartz. The resonant frequency depends on size, shape, elasticity, and the speed of sound in the material. High-frequency crystals are typically cut in the shape of a simple rectangle or circular disk. Low-frequency crystals, such as those used in digital watches, are typically cut in the shape of a tuning fork. For applications not needing very precise timing, a low-cost ceramic resonator is often used in place of a quartz crystal.

When a crystal of quartz is properly cut and mounted, it can be made to distort in an electric field by applying a voltage to an electrode near or on the crystal. This property is known as electrostriction or inverse piezoelectricity. When the field is removed, the quartz generates an electric field as it returns to its previous shape, and this can generate a voltage. The result is that a quartz crystal behaves like an RLC circuit, composed of an inductor, capacitor and resistor, with a precise resonant frequency.

Quartz has the further advantage that its elastic constants and its size change in such a way that the frequency dependence on temperature can be very low. The specific characteristics depend on the mode of vibration and the angle at which the quartz is cut (relative to its crystallographic axes).[13] Therefore, the resonant frequency of the plate, which depends on its size, does not change much. This means that a quartz clock, filter or oscillator remains accurate. For critical applications the quartz oscillator is mounted in a temperature-controlled container, called a crystal oven, and can also be mounted on shock absorbers to prevent perturbation by external mechanical vibrations.

Resonance modes

A quartz crystal provides both series and parallel resonance. The series resonance is a few kilohertz lower than the parallel one. Crystals below 30 MHz are generally operated between series and parallel resonance, which means that the crystal appears as an inductive reactance in operation, this inductance forming a parallel resonant circuit with externally connected parallel capacitance. Any small additional capacitance in parallel with the crystal pulls the frequency lower. Moreover, the effective inductive reactance of the crystal can be reduced by adding a capacitor in series with the crystal. This latter technique can provide a useful method of trimming the oscillatory frequency within a narrow range; in this case inserting a capacitor in series with the crystal raises the frequency of oscillation. For a crystal to operate at its specified frequency, the electronic circuit has to be exactly that specified by the crystal manufacturer. Note that these points imply a subtlety concerning crystal oscillators in this frequency range: the crystal does not usually oscillate at precisely either of its resonant frequencies.

Crystals above 30 MHz (up to >200 MHz) are generally operated at series resonance where the impedance appears at its minimum and equal to the series resistance. For these crystals the series resistance is specified (<100 Ω) instead of the parallel capacitance. To reach higher frequencies, a crystal can be made to vibrate at one of its overtone modes, which occur near multiples of the fundamental resonant frequency. Only odd numbered overtones are used. Such a crystal is referred to as a 3rd, 5th, or even 7th overtone crystal. To accomplish this, the oscillator circuit usually includes additional LC circuits to select the desired overtone.

Temperature effects

A crystal's frequency characteristic depends on the shape or "cut" of the crystal. A tuning-fork crystal is usually cut such that its frequency dependence on temperature is quadratic with the maximum around 25 °C. This means that a tuning-fork crystal oscillator resonates close to its target frequency at room temperature, but slows when the temperature either increases or decreases from room temperature. A common parabolic coefficient for a 32 kHz tuning-fork crystal is −0.04 ppm/°C^2:

$$f=f_0\,[1-0.04\ \text{ppm}/{}^{\circ}\text{C}^2 \cdot (T-T_0)^2$$

In a real application, this means that a clock built using a regular 32 kHz tuning-fork crystal keeps good time at room temperature, but loses 2 minutes per year at 10 °C above or below room temperature and loses 8 minutes per year at 20 °C above or below room temperature due to the quartz crystal.

Crystal oscillator circuits

The crystal oscillator circuit sustains oscillation by taking a voltage signal from the quartz resonator, amplifying it, and feeding it back to the resonator. The rate of expansion and contraction of the quartz is the resonant frequency, and is determined by the cut and size of the crystal. When the energy of the generated output frequencies matches the losses in the circuit, an oscillation can be sustained.

An oscillator crystal has two electrically conductive plates, with a slice or tuning fork of quartz crystal sandwiched between them. During startup, the controlling circuit places the crystal into an unstable equilibrium, and due to the positive feedback in the system, any tiny fraction of noise is amplified, ramping up the oscillation. The crystal resonator can also be seen as a highly frequency-selective filter in this system: it only passes a very narrow subband of frequencies around the resonant one, attenuating everything else. Eventually, only the resonant frequency is active. As the oscillator amplifies the signals coming out of the crystal, the signals in the crystal's frequency band becomes stronger, eventually dominating the output of the oscillator. The narrow resonance band of the quartz crystal filters out all the unwanted frequencies.

The output frequency of a quartz oscillator can be either that of the fundamental resonance or of a multiple of that resonance, called a harmonic frequency. Harmonics are an exact integer multiple of the fundamental frequency. But, like many other mechanical resonators, crystals exhibit several modes of oscillation, usually at approximately odd integer multiples of the fundamental frequency. These are termed "overtone modes", and oscillator circuits can be designed to excite them. The overtone modes are at frequencies which are approximate, but not exact odd integer multiples of that of the fundamental mode, and overtone frequencies are therefore not exact harmonics of the fundamental.

High frequency crystals are often designed to operate at third, fifth, or seventh overtones. Manufacturers have difficulty producing crystals thin enough to produce fundamental frequencies over 30 MHz. To produce higher frequencies, manufacturers make overtone crystals tuned to put the 3rd, 5th, or 7th overtone at the desired frequency, because they are thicker and therefore easier to manufacture than a fundamental crystal that would produce the same frequency—although exciting the desired overtone frequency requires a slightly more complicated oscillator circuit. A fundamental crystal oscillator circuit is simpler and more efficient and has more pullability than a third overtone circuit. Depending on the manufacturer, the highest available fundamen-

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89 countries, 33 governments use Hallicrafters equipment. These precision instruments are prized by experts, remembered by veterans, and preferred throughout the world by short-wave listeners who want a radio that is all radio.

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Model S-40B, S-77—New version of an old favorite. Temperature compensated oscillator; tuned r-f stage, two i-f stages for better selectivity. Covers 540 kc to 43 Mc in four bands. Sensitivity, volume, three-position Tone, BFO Pitch, controls; AVC, BFO, Rec./Standby, and Noise Limiter Switches. Built-in PM speaker. External power, remote control connections. 7 tubes plus rectifier...............**$99.95**

Model SR-75—A small transceiver for the novice class or beginning amateur; can also be used later as exciter unit. Receives on 540 kc through 32 Mc, transmits on 10, 11, 20, 40, or 80 meter bands. 10 watts input to final amp. Receiving section is substantially same as our S-38B Bandspread tuning, Speaker/phones switch, BFO switch. Rec./Standby switch; four tubes plus rectifier. Transmitting section uses electron coupled Xtal oscillator plus output tube of receiver. Voltage doubler rectifier to increase plate voltage. 5 tubes plus rectifier. With coils, less crystals...**$89.95**

Model S-38B—Pulls in broadcast stations in weak signal areas where ordinary sets fail. Also offers world-wide reception for the short-wave listener and the new amateur. Covers Broadcast Band and three short-wave bands. 540 kc to 32 Mc. Separate Fine Tuning control. BFO, Rec./Standby. Speaker/Phones switches. Built-in PM speaker. Four tubes plus rectifier. For 115 V. AC or DC. **$49.50**

S-72—One stage r-f, two stages i-f amplification. Built-in loop antenna for broadcast, plus 61" collapsible whip for short-wave. Band-spread tuning knob for separation of short-wave stations. Sensitivity control combined with code (BFO) switch, Jack for headphones. Brown leatherette cabinet, space inside for power cord and headphones. 8 tubes plus rectifier. Less batteries. For 115 V, AC or DC or batt. 540 kc. to 30,5 Mc. in 4 bands.......**$109.95**
S-72L (Long Wave Model)—Marine Beacons, Aircraft Ranges, Towers 175-420 kc., Plus 540 kc. 12.5 Mc. **$119.95**

Model SX-62

Model SX-71

Model S-76

Model S-40B, S-77

Model SR-75

Model S-38B

S-72, S-72L

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7

tal frequency may be 25 MHz to 66 MHz.

A major reason for the wide use of crystal oscillators is their high Q factor. A typical *Q* value for a quartz oscillator ranges from 10^4 to 10^6, compared to perhaps 10^2 for an LC oscillator. The maximum *Q* for a high stability quartz oscillator can be estimated as $Q = 1.6 \times 10^7/f$, where *f* is the resonant frequency in megahertz.

One of the most important traits of quartz crystal oscillators is that they can exhibit very low phase noise. In many oscillators, any spectral energy at the resonant frequency is amplified by the oscillator, resulting in a collection of tones at different phases. In a crystal oscillator, the crystal mostly vibrates in one axis, therefore only one phase is dominant. This property of low phase noise makes them particularly useful in telecommunications where stable signals are needed, and in scientific equipment where very precise time references are needed.

Environmental changes of temperature, humidity, pressure, and vibration can change the resonant frequency of a quartz crystal, but there are several designs that reduce these environmental effects. These include the TCXO, MCXO, and OCXO which are defined below. These designs, particularly the OCXO, often produce devices with excellent short-term stability. The limitations in short-term stability are due mainly to noise from electronic components in the oscillator circuits. Long-term stability is limited by aging of the crystal.

Due to aging and environmental factors (such as temperature and vibration), it is difficult to keep even the best quartz oscillators within one part in 10^{10} of their nominal frequency without constant adjustment. For this reason, atomic oscillators are used for applications requiring better long-term stability and accuracy.

Spurious frequencies

For crystals operated at series resonance or pulled away from the main mode by the inclusion of a series inductor or capacitor, significant (and temperature-dependent) spurious responses may be experienced. Though most spurious modes are typically some tens of kilohertz above the wanted series resonance their temperature coefficient is different from the main mode and the spurious response may move through the main mode at certain temperatures. Even if the series resistances at the spurious resonances appear higher than the one at wanted frequency a rapid change in the main mode series resistance can occur at specific temperatures when the two frequencies are coincidental. A consequence of these activity dips is that the oscillator may lock at a spurious frequency at specific temperatures. This is generally minimized by ensuring that the maintaining circuit has insufficient gain to activate unwanted modes.

Spurious frequencies are also generated by subjecting the crystal to vibration. This modulates the resonant frequency to a small degree by the frequency of the vibrations. SC-cut crystals are designed to minimize the frequency effect of mounting stress and they are therefore less sensitive to vibration. Acceleration effects including gravity are also reduced with SC-cut crystals as is frequency change with time due to long term mounting stress variation. There are disadvantages with SC-cut shear mode crystals, such as the need for the maintaining oscillator to discriminate against other closely related unwanted modes and increased frequency change due to temperature when subject to a full ambient range. SC-cut crystals are most advantageous where temperature control at their temperature of zero temperature coefficient (turnover) is possible, under these circumstances an overall stability performance from premium units can approach the stability of Rubidium frequency standards.

Commonly used crystal frequencies

Crystals can be manufactured for oscillation over a wide range of frequencies, from a few kilohertz up to several hundred megahertz. Many applications call for a crystal oscillator frequency conveniently related to some other desired frequency, so hundreds of standard crystal frequencies are made in large quantities and stocked by electronics distributors. For example 3.579545 MHz crystals, which are made in large quantities for NTSC color television receivers, are popular for many non-television applications uses too. Using frequency dividers, frequency multipliers and phase-locked loop circuits, it is practical to derive a wide range of frequencies from one reference frequency.

Crystal structures and materials

Quartz

The most common material for oscillator crystals is quartz. At the beginning of the technology, natural quartz crystals were used but now synthetic crystalline quartz grown by hydrothermal synthesis is predominant due to higher purity, lower cost and more convenient handling. One of the few remaining uses of natural crystals is for pressure transducers in deep wells. During World War II and for some time afterwards, natural quartz was considered a strategic material by the USA. Large crystals were imported from Brazil. Raw "lascas", the source material quartz for hydrothermal synthesis, are imported to USA or mined locally by Coleman Quartz. The average value of as-grown synthetic quartz in 1994 was 60 USD/kg.

Types

Two types of quartz crystals exist: left-handed and right-handed. The two differ in their optical rotation but they are identical in other physical properties. Both left and right-handed crystals can be used for oscillators, if the cut angle is correct. In manufacture, right-handed quartz is generally used.[25] The SiO_4 tetrahedrons form parallel helices; the direction of twist of the helix determines the left- or right-hand orientation. The helixes are aligned along the z-axis and merged, sharing atoms. The mass of the helixes forms a mesh of small and large channels parallel to the z-axis. The large ones are large enough to allow some mobility of smaller ions and molecules through the crystal.

Quartz exists in several phases. At 573 °C at 1 atmosphere (and at higher temperatures and higher pressures) the α-quartz undergoes quartz inversion, transforms reversibly to β-quartz. The reverse process however is not entirely homogeneous and crystal twinning occurs. Care must be taken during manufacturing and processing to avoid phase transformation. Other phases, e.g. the higher-temperature phases tridymite and cristobalite, are not significant for oscillators. All quartz oscillator crystals are the α-quartz type.

Quality

Infrared spectrophotometry is used as one of the methods for measuring the quality of the grown crystals. The wavenumbers 3585, 3500, and 3410 cm^{-1} are commonly used. The measured value is based on the absorption bands of the OH radical and the infrared Q value is calculated. The electronic grade crystals, grade C, have Q of 1.8 million or above; the premium grade B crystals have Q of 2.2 million, and special premium grade A crystals have Q of 3.0 million. The Q value is calculated only for the z region; crystals containing other regions can be adversely affected. Another quality indicator is the etch channel density; when the crystal is etched, tubular channels are created along linear defects. For processing involving etching, e.g. the wristwatch tuning fork crystals, low etch channel density is desirable. The etch channel density for swept quartz is about 10–100 and significantly more for unswept quartz. Presence of etch channels and etch pits degrades the resonator's Q and introduces nonlinearities.

Other materials

Some other piezoelectric materials than quartz can be employed. These include single crystals of lithium tantalate, lithium niobate, lithium borate, berlinite, gallium arsenide, lithium tetraborate, aluminium phosphate, bismuth germanium oxide, polycrystalline zirconium titanate ceramics, high-alumina ceramics, silicon-zinc oxide composite, or dipotassium tartrate. Some materials may be more suitable for specific applications. An oscillator crystal can be also manufactured by depositing the resonator material on the silicon chip surface. Crystals of gallium phosphate, langasite, langanite and langatate are about 10 times more pullable than the corresponding quartz crystals, and are used in some VCXO oscillators.

Command Receivers

Bill ZS6WP

These excellent little receivers could be bought back in the late 1950's for as little as 10/- to 15/- (10 to 15 shillings old money). Several models were available all with a different segment of the band. The coverage went from L.F to HF. I still had one of the L.F versions the BC-453B which had been up and down over the years to the West Rand Flea Market.

I was surprised the BC-453B had never attracted any takers. The main reason I suppose is many of the Flea Market visitors were not aware of what the little gem could do, many may not have been born at that time. Few would feel comfortable around the H.T. voltage of some 150 to 200 volts.

My BC-453B was never modified and only used to listen for propagation on the L.F. segment. Knowing the air field and the call sign of the NDB (non-directional aircraft beacon) one could access propagation conditions which often stretched down to H.F.

Feeling the effects of waiting for parts from China I was suffering from fault finding withdrawal symptoms. I scratched around in the top cupboard of the wardrobe and there was the BC-453B and a suitable power supply. The results from the NDB's were disappointing. The introduction of G.P.S has largely made old school navigation obsolete.

As NDB's fail and parts as well as experienced technicians become unobtainable the beacons are taken off the air and scrapped. What will happen in the event of a major CME (coronal mass ejection) wiping out satellites and the global positioning system, who knows?

I decided after some 60 years to add a front-end converter to the BC-453B and get it onto an amateur band. 40 meters became my choice. Such converters were once popular as a low-cost way for beginners to find a receiver. The conversions were known as Q-5r's.

My version of the Q-5r uses an ECC82 and a 7,508 MHz crystal from my collection. There's nothing new or unusual about the converter. Lots of other examples can be found on the web. Available parts should determine what Q-5r circuit to go for. I considered an ECH91 but decided just one grid in each stage would do the job.

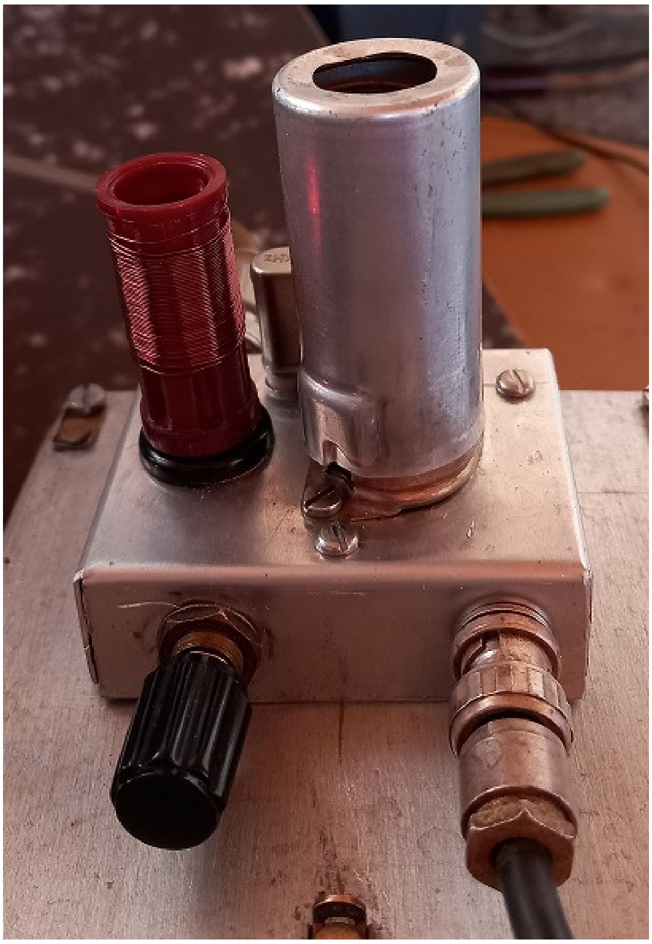
I'd almost finished the project on Friday night and wanted to see how the conversion performed. The BBC on 7,265 MHz was fine on Friday but what about 40 meters SSB?

Saturday morning came along and there was ZS2E on 7,085 MHz overloading the receiver. I reduced the gain through a front panel control fitted back in the day. The SSB reception was excellent and less drift than my FT-One.

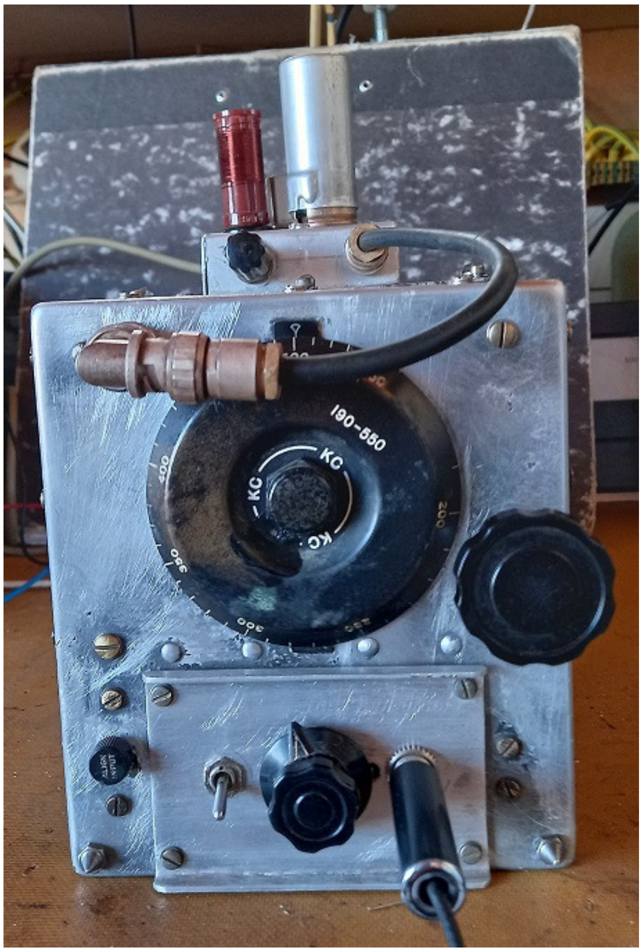
Later there was Andy and the AWA net 5 & 8 to 9 all the way. Just some finishing touches and I had a working 40 meter receiver. All it took to finish the project was to screw down the converter to the top of the BC-455B.

Now where are those chips from China that arrived in SA customs at the end of April?

(Pictures on next page)



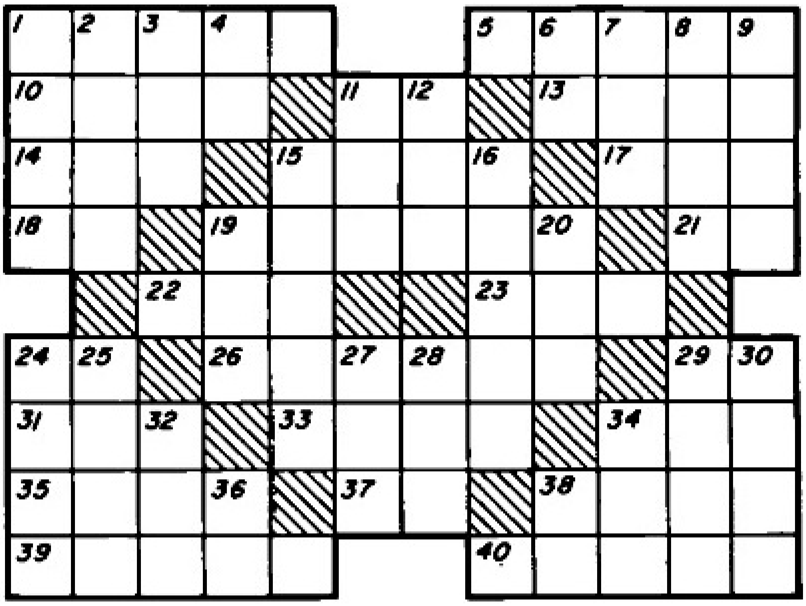
BC453B Converter



BC453B Front View

BC453 Label

ELECTRONICS CROSSWORD PUZZLE



Across

1.Electromechanical man.
5. White ----.
10. March days.
11. Pronoun.
13. Norse goddess.
14. Obtain.
15. To trim.
17. Circuit used in s.w. receivers: abbrev.
18. Selenium rectifier: symbol.
19. Transceiver manufacturer.
21. Shilling: abbrev.
22. Heater or filament: schematic abbrev.
23. To discard.
24. ---- tube.
26. Amateur license class.
29. Table of Operations: Army abbrev.
31. Solder ----
33. Reckless.
34. Fire residue.
35. Island.
37. Normally open: schematic abbrev.
38. 1/16 of an ounce.
39. C.W. or ----.
40. Long-distance "hounds."

Down

1.Ham equipment: pl.
2. River in Germany.
3. Wager.
4. Osmium: symbol
6. Preposition.
7. Man's name.
8. Incoming ----: (pl.) abbrev.
9. ---- and everyone.
11. Vase -like vessel.
12. Morse code for "help."
15. ---- code.
16. Birds do it.
19. Separates seeds from fibers.
25. ---- order.
27. Type of truck.
28. ----tope.
29. Eastern king.
30. ---- Law.
32. ----bar thermistor.
34. To be: pl.
36. Printer's measure.
38. SWL talk for long distance.

Substrata Communications
January 1968 Popular Electronics

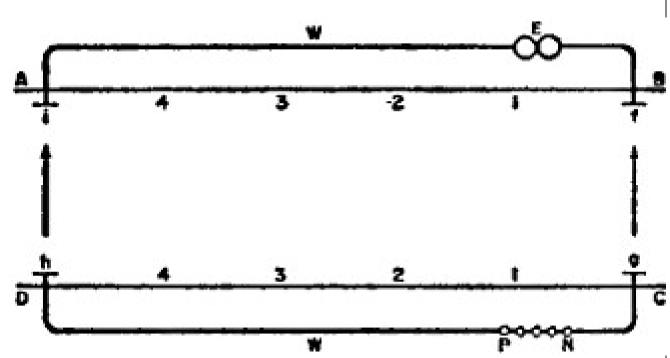
Benjamin Franklin is credited with many inventions; scientific experiments and discoveries; writings on science, government, and fiction; skills as an orator and diplomat; printer of books and newspapers; business endeavours; and for being the nation's first Postmaster General. Although we all are familiar with his forays into things electrical in nature like flying kites in lightning storms, this article from a 1968 issue of Popular Electronics introduces us to what might have been the earliest "wireless" communications demonstration. The scheme involved the equivalent of the old lab gag of charging up a large-valued electrolytic capacitor and then tossing it to someone, resulting in a surprising shock. As with many of you, I have been both the victim and purveyor of said mischief. In Franklin's case, the "wireless" medium was water in a river, upon whose banks a pair of wires, each connected to two metal plates, was erected. The capacitor used was in the form of a Leyden jar - akin to the one used in his lightning experiment. Read on for the details.

The Mystery of Radio Waves That Travel Along or Beneath the Surface of the Earth

By Russell E. Adams, Jr.

Although it is not common knowledge, the history of electrical communications goes way back to 1748 - predating Samuel Morse's invention of the telegraph by almost a hundred years. The actual credit for the first electrical communications system can go to Benjamin Franklin.

On a spring-like day in late April, 1748, Benjamin Franklin held a picnic along one bank of the Schuylkill River in Philadelphia. The guests present were entertained with a series of electrical demonstrations, the first of which was the firing of several guns-using an electric spark to ignite the charges. This was followed by the electric-shock slaughtering of the turkeys for the picnic. The turkeys were, in turn, roasted over fires that had been kindled with another electric spark.



In diagram drawn by Samuel Morse, AB and CD represent opposite banks of a river; f, g, h, and i are

As the afternoon drew to a close, Benjamin Franklin requested a volunteer from among his guests. The volunteer was asked to place a hand on each of two metal plates that had been nailed to the top of a table. A wire, connected to each plate, terminated in the waters of the river.

Benjamin Franklin told his guests that an assistant was stationed on the opposite bank of the river with a similar apparatus, and that when a signal was given, the assistant would momentarily place a charged Leyden jar across the plates on his apparatus. The signal was given, and the volunteer immediately jumped away from the table - he had received a mild electric shock. The electric charge had travelled from one bank to the other solely through the medium of water.

This was the first demonstration of "ground communications," but unfortunately, Benjamin Franklin did not realize the full implications of his discovery.

It was not until many years later that ground communications was to become known and successfully utilized.

Ground communications, as demonstrated by Benjamin Franklin, depends on a physical flow of current (termed "ionic charge carriers") through a conducting medium between the "transmitter" and the "receiver." A continuous conductive medium is required, so that the atmosphere - a non-conductive medium, to say the least - cannot be utilized to establish point-to-point ground communications.

Among the first experimenters with the ground communications phenomenon was Samuel F.B. Morse. On December 16, 1842, he transmitted code messages from one side of a river to the other without connecting wires. The diagram of his apparatus is shown below; note the similarity between the diagram and the description of Franklin's setup. Instead of a Leyden jar and human contact with the "receiver" side, Morse used batteries (P and N denoting positive and negative) and headphones, denoted by E.

Perhaps the earliest documented use of ground communications for transmitting voice messages dates back to 1902. In that year, Nathan Stubblefield, an inventor from Kentucky, broadcasted voice messages from the steamer Bartholdi to members of Congress on the shore of the Potomac River - a distance of about a half-mile.

The military history of ground communications had its beginning in the 46 early part of World War I. A French unit, trapped in the Argonne Forest by a strong encircling force of Germans, was running low on ammunition and needed reinforcements. But the encirclement was so complete that heavy losses would be the price the main body of French troops would have to pay to mount a rescue. The trapped unit, however, was in a position to observe the enemy forces. If up-to-the-minute and steady communications could be established, it could turn the tide of battle.

Fortunately, a signalman with the trapped unit had heard of ground communications. He constructed a "transmitter," using the field telegraph set and two bayonets driven into the ground about six feet apart. A runner was sent through the German lines with instructions for the French army to assemble a simple "receiver," consisting of two bayonets and a pair of headphones. The subsequent flow of tactical information coming from the trapped unit turned a nearly impossible situation into victory as the French army suddenly broke through the enemy lines.

When the Audion tube was invented, the French learned that they could also use ground communications techniques to intercept German telephone messages. At that time, the German telephone system employed a single wire strung from station to station, with the earth as the return current path to complete the circuit. Two bayonets again became a pickup antenna, and an Audion amplifier and headphones were the receiver. The grounded connections at the German telephone stations served as the transmitting antenna electrodes.

Between World War I and about the mid-1950's, very little military research into ground communications was conducted. But private and government research was stimulated. During World War II, ground communications was utilized to a limited extent by radio amateurs who had been forced off the air to make the spectrum space available for military operations. The American Radio Relay League (ARRL) , an amateur radio organization, conducted experiments with ground communications. The ARRL concluded, however, that ground communications was much less efficient than radio.

Then, in 1948, the U.S. Bureau of Mines began to experiment with ground communications transceivers in coal, iron, and salt mines. Primary communications were still relegated to the field telephone, but in cave-ins, where phone lines were often cut by falling rock, ground communications was intended to provide contact between rescue teams and the trapped workers. A great deal of success was achieved with this system.

Perhaps the first serious attempt by the U.S. Department of Defence to utilize ground communications began with the introduction of the nuclear submarine. Since the new submarines were designed and built for long-term, deep-water cruising, it was evident that the then current 50-foot maximum penetration depth of VLF communications systems would be inadequate. For a nuclear submarine to communicate via VLF, it would have to practically surface or release a floating antenna to receive radio signals, putting the submarine in a vulnerable position.

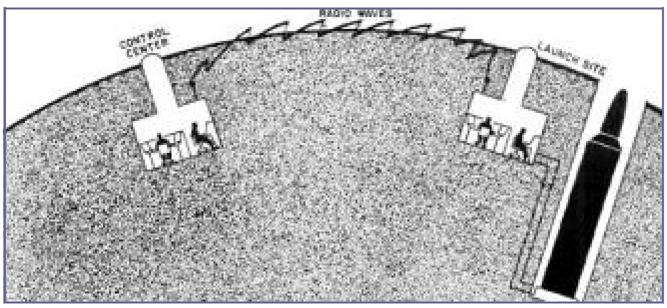
The Navy's first ground communications experiments with submarines were held at the Naval Air Station in Lakehurst, New Jersey. A dirigible was equipped with a ground communications transceiver. Antenna electrodes were affixed to the transceiver and dirigible in such a manner that they could be lowered into the water. The submarines were equipped with similar equipment.

In the beginning, the tests indicated that greater-than-fifty-foot depths could be achieved, but the transmission range was limited to a few miles - not enough to satisfy the Navy's needs. However, enough progress was made each year to keep the Navy interested. Whether such a system is operational at the present time is not known.

Two accidental discoveries were made by the Navy during this research. It was found that high-energy electrons oscillating from pole to pole generated about a 10-Hz signal that could be detected by the ground communications equipment, suggesting the possibility of using ground communications as a means of detecting atmospheric tests of nuclear weapons. It was also discovered that the system could be utilized to detect cruising submarines. (The electrolytic action of the sea water on the propeller and hull creates a d.c. field around the submarine, and as the propeller turns, the lubricant on the shaft produces an intermittent circuit. The resulting fluctuations in the d.c. field were easily detected.) While the situation that caused detection could easily be remedied, the potential of ground communications as an anti-submarine warfare weapon was demonstrated.

The Air Force became interested in ground communications techniques in 1958, during the height of the nuclear arms race. The ICBM's designed for delivering nuclear warheads to the targets had to be protected against destruction, so they were housed in "hardened" silos deep in the earth. This deep-earth silo setup gave rise to another problem - that of jam-proof communications.

In July, 1958, Space Electronics Corporation (now Space-General Corporation, a division of Aero-Jet General) was formed in California to investigate ground communications for the Air Force. Instead of ionic charge carriers, low-frequency radio waves were used to transmit the information from site to site. The system was based on a special application of the wave equations formulated by Drs. A. Sommerfield and J. Zanneck, wherein the angle of refraction of a radio wave can be controlled by the proper selection of frequency.



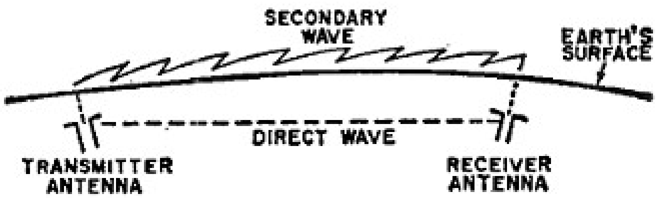
Radio waves from underground launch control center transmitter travel along earth's surface. the Some of energy is reabsorbed into the earth and picked up by underground launch site's receiving antenna.

Space Electronics Corporation utilized this principle in its experiments at Newport Harbour, and later across the Glendale Grand-Central Airport, both in California. The transmitter and receiver dipole antennas were buried less than 50 meters below the surface of the earth (the silo centres were much deeper). Radio waves from the transmitting antenna travelled toward the surface of the earth. The r.f. energy that was not reflected back passed through the earth/air interface, or barrier, and continued along the surface. As the wave front moved along the surface, it was constantly attenuated, and some of the energy was reabsorbed into the earth to be intercepted by the receiving antenna.

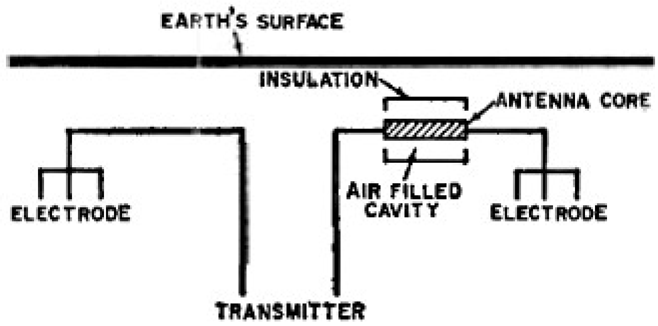
The system developed for the Air Force employed the "up-over-down" (UOD) technique. Signals generated by the transmitter were detected by VLF receivers placed only a few feet above the ground. The operating frequencies used for the tests were less than 200 kHz, and the maximum distance achieved was less than 50 miles.

In February of 1961, the UOD system was adopted by the Air Force as a means of providing underground communications between missile silos and launch control centres. At the present time, this system is employed at all Minuteman missile bases, reportedly saving some $300,000 per missile.

Another method of ground communications, differing from the UOD system in that radio signals are transmitted directly through the earth instead of along the surface, was developed next. Normally, a through-the-earth system would have a very limited range (less than a few hundred feet). If the antenna were placed only a few meters below the earth's surface as in the UOD system, the relatively high conductivity of the earth's crust would act like the metal shield of a coaxial cable, rapidly attenuating the signal. However, the companies involved (among them Raytheon and International Telephone and Telegraph) in the development of the new system employed the wave guide principle. The geological structure of the earth itself was used as a natural wave guide.



In the "up-over-down" system, the secondary wave is the primary transmission path. The direct wave, attenuated by the earth through which it passes, does not propagate very far.



Details of UOD transmitting dipole antenna.

This geological structure has certain electrical properties that are quite similar to those in man-made wave guides. From the earth's surface to a depth of between 700 and 1700 feet, the "crust" of the earth is a relatively good conductor. Below this "crust" is a rocky layer (mostly non-conducting granite) that forms a part of the Precambrian "basement complex," the thickness of which varies between 3500 and 6500 feet. A third layer that forms a part of the earth's "core" and extends to a depth of greater than 16,500 feet is characterized by increasing conductivity with increasing depth.

These three layers - crust, basement complex, and core - form a sandwich which is not unlike a wave guide. Between the conducting core and crust, the basement complex can be likened to the non-conducting air space inside a manmade wave guide. Although the sandwich structure of the earth behaves in a manner similar to a man-made wave guide, the non-conducting solid layer dampens signals to a much greater degree than air.

In June, 1952, the Raytheon Corporation began experiments with this "deep rock strata" communications system, in Brewster, Cape Cod. A 300-watt transmitter was used; a narrow-band wave analyser served as the receiver. Transmission distances up to 1.1 miles were obtained for frequencies up to 10 kHz, but attempts to increase that distance were unsuccessful. An examination of geological formations indicated that long-distance transmissions were impractical in that region.

Additional experiments were conducted in the Adirondack Mountains, where the formation of the basement complex was more favourable for long-distance transmissions, and deeper holes could be drilled for the long resonant antennas. From these experiments, Raytheon scientists concluded that transmission distances in the tens of miles were practical.

The deep rock strata communications system has one unique advantage over both the ionic charge carrier and UOD systems - the conductive overburden of the crust forms a shield to natural and man-made interference.

In this modern age of communications satellites and lasers, ground communications might seem to be out of place. But it can play an ever-increasing role in solving unusual communications problems. For example, it can provide destruction-proof communications networks for the Department of Defence. Based on ground communications techniques, undersea radar may someday become a reality.

There is also the distinct possibility that ground communications may provide the answer to over-the-horizon communications problems that will plague colonization of the moon. Because the moon's radio horizon is so close, by comparison to that of the earth, plus the absence of a radio-wave-reflective ionosphere, only two alternatives are left for site-to-site communications. Moon-to-earth-to-moon relay and orbiting lunar satellite. If, on the other hand, ground communications techniques can be employed, this potentially vexing problem may be solved.

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